



PERGAMON

Microelectronics Reliability 38 (1998) 1979–1992

**MICROELECTRONICS  
RELIABILITY**

## Contents of Volume 38

### NUMBER 1

N. Stojadinović and M. Pecht

iii Editorial

C. Hu

*Introductory Review Paper*

1 Reliability phenomena under AC stress

D. Vuillaume, A. Bravaix and  
D. Goguenheim

**HOT CARRIERS**

*Review Paper*

7 Hot-carrier injections in SiO<sub>2</sub>

P. Vasina, E. Simoen, C. Claeys and  
J. Sikula

*Research Papers*

23 A low-frequency noise study of hot-carrier stressing effects in submicron Si p-MOSFETs

L. K. J. Vandamme and X. Li

29 Change in d.c. and 1/f noise characteristics of *n*-submicron MOSFETs due to hot-carrier degradation

### OXIDE DEGRADATION AND BREAKDOWN

A. Martin, P. O'Sullivan and  
A. Mathewson

*Review Paper*

37 Dielectric reliability measurement methods: a review

T. Brožek, Y. D. Chan  
and C. R. Viswanathan

*Research Papers*

73 Gate oxide leakage due to temperature accelerated degradation under plasma charging conditions

S. V. Nguyen, T. Nguyen, D. Carl,  
D. Pricer, J. W. Korejwa  
and D. Dobuzinsky

81 Ultrathin RTP oxynitrides dielectrics on planar, trench and three dimensional structures

### ELECTROMIGRATION

W. A. De Ceuninck, V. D'Haeger,  
J. Van Olmen, A. Witvrouw, K. Maex,  
L. De Schepper, P. De Pauw  
and A. Pergoot

*Review Paper*

87 The influence of addition elements on the early resistance changes observed during electromigration testing of Al metal lines

T. J. Moushaan and V. Petrescu

*Research Papers*

99 The modeling of resistance changes in the early phase of electromigration

S. Foley, A. Ryan, D. Martin  
and A. Mathewson

107 A study of the influence of inter-metal dielectrics on electromigration performance

### ESD

K. Verhaege

*Review Paper*

115 Component level ESD testing

A. H. Olney

*Research papers*

129 Using charged device model testing to eliminate real-world ESD failures

S. Voldman, J. Never, S. Holmes and  
J. Adkisson

145 Linewidth control effects on MOSFET ESD robustness

### COMPOUND DEVICES

K. A. Christianson

*Review Paper*

153 Reliability of III–V based heterojunction bipolar transistors

- S. Sheu, J. J. Liou and C. I. Huang**
- Jae Kyoung Mun, Jong-Lam Lee, Haecheon Kim, Byung-Taek Lee, Jae Jin Lee and Kwang-Eui Pyun**
- Research Papers*
- 163 Numerical analysis on determining the physical mechanisms contributing to the abnormal base current in post-burn-in AlGaAs/GaAs HBTs
- 171 Degradation mechanism of GaAs MESFETs

## NUMBER 2

### SPECIAL ISSUE

### DIELECTRICS IN MICROELECTRONICS

- A. Paccagnella and E. Zanoni**      iii Editorial

#### SECTION I: FLASH MEMORIES AND RELATED TECHNOLOGIES

- Review Papers*
- C. Golla and S. Ghezzi**      179 Flash memory architecture
- P. Cappelletti**      185 Flash memory reliability
- Research Papers*
- A. Candelori, E. Gomiero, G. Ghidini and A. Paccagnella**      189 MOSFET parameter degradation after Fowler–Nordheim injection stress
- A. Scarpa, G. Ghibaudo, G. Ghidini, G. Pananakakis and A. Paccagnella**      195 Stress induced degradation features of very thin gate oxides

#### SECTION II: RELIABILITY OF THIN DIELECTRICS FOR VLSI AND RELATED TESTING METHODS

- Review Paper*
- E. Cartier**      201 Characterization of the hot-electron-induced degradation in thin SiO<sub>2</sub> gate oxides
- Research Papers*
- A. J. Bauer and E. P. Bulte**      213 4 nm gate dielectrics prepared by RTP low pressure oxidation in O<sub>2</sub> and N<sub>2</sub>O atmosphere
- G. Ghidini, M. Alessandri, C. Clementi and F. Pellizzer**      217 Influence of charge trapping on oxide scaling down
- A. Meinertzhagen, C. Petit, G. Yard, M. Jourdain and F. Mondon**      221 Effect of the discharging and recharging of the stress generated oxide charge in metal–oxide–semiconductor capacitors on the low field leakage current
- G. Auriel, J. Oualid and D. Vuillaume**      227 Electron traps created in gate oxides by Fowler–Nordheim injections
- C. Leveugle, P. K. Hurley, A. Mathewson, S. Moran, E. Sheehan and A. Kalnitsky**      233 Observation of high interface state densities at the silicon/oxide interface for low doped polysilicon/oxide/silicon capacitor structures
- A. Pacelli, A. L. Lacaita, A. Spinelli and R. Bez**      239 Effect of N<sub>2</sub>O nitridation on the electrical properties of MOS gate oxides
- R. Beyer, H. Burghardt, R. Reich, E. Thomas, T. Gessner and D. R. T. Zahn**      243 Structural properties and electrical behaviour of thin silicon oxynitride layers
- C. Pennetta, Z. Gingl, L. B. Kiss, L. Reggiani, M. De Vittorio, A. Cola and M. Mazzer**      249 A percolative simulation of dielectric-like breakdown
- G. Ghidini, C. Clementi, D. Drera and F. Maugain**      255 The impact of F contamination induced by the process on the gate oxide reliability

## SECTION III: CHARACTERIZATION OF TRENCH AND INTERMETAL DIELECTRICS

- Review Paper*
- D. R. Wolters and A. T. A. Zegers-van Duijnhoven 259 Advanced modeling of silicon oxidation
- Research Papers*
- V. Em. Vamvakas, D. Davazoglou and C. Vahlas 265 Thermodynamic study, compositional and electrical characterization of LPCVD SiO<sub>2</sub> films grown from TEOS/N<sub>2</sub>O mixtures
- P. Sallagoity, F. Gaillard, M. Rivoire, M. Paoli, M. Haond and S. McClathie 271 STI process steps for sub-quarter micron CMOS
- J. H. Klootwijk, H. van Kranenburg, M. H. H. Weusthof, P. H. Woerlee and H. Wallinga 277 RTP annealings for high-quality LPCVD interpolysilicon dielectric layers
- D. J. den Boer, H. Fukuda, J. Helmig, J. B. C. van der Hilst, G. C. A. M. Janssen, A. J. Kalkman and S. Radelaar 281 SiOF and SiO<sub>2</sub> deposition in a HDP reactor: tool characterization and film analysis
- E. Bär, J. Lorenz and H. Ryssel 287 Experimental verification of three-dimensional simulations of LTO layer deposition on structures prepared by anisotropic wet etching of silicon
- 293 List of reviewers

## NUMBER 3

- Introductory Invited Paper*
- J. Tao, B.-K. Liew, J. F. Chen, N. W. Cheung and C. Hu 295 Electromigration under time-varying current stress
- Research Papers*
- P. Cosemans, J. D'Haen, A. Witvrouw, J. Proost, M. D'Olieslaeger, W. De Ceuninck, K. Maex and L. De Schepper 309 Study of Cu diffusion in an Al-1 wt.%Si-0.5 wt.%Cu bond pad with an Al-1 wt.%Si bond wire attached using scanning electron microscopy
- R. Ubar 317 Combining functional and structural approaches in test generation for digital systems
- T. Trajković, P. Igić and N. Stojadinović 331 A novel method for extraction of VDMOSFET model parameters using neural networks
- M. M. Jevtić 337 Anomalous *I-V* and pulse noise in reverse biased p-n junctions
- C.-S. Cheng, Y.-T. Hsu and C.-C. Wu 345 An improved neural network realization for reliability analysis
- J. A. Scalise 353 Qualification of plastic encapsulated microcircuits (PEM) for avionics
- R.-C. Liu and W.-C. Liu 361 Comparison of surface recombination effect in GaAs-based heterostructure-emitter and heterostructure-base transistors (HEHBTs)
- R.-C. Liu and W.-C. Liu 367 Comparison of modulation doped effect in negative differential resistance field effect transistors (NDRFETs)
- M. Jargelius, U. Gustafsson and M. Bakowski 373 EBIC analysis of SiC mesa diodes
- M. Bakowski, U. Gustafsson and Z. Ovuka 381 Walk-out phenomena in 6H-SiC mesa diodes with SiO<sub>2</sub>/Si<sub>3</sub>N<sub>4</sub> passivation and charge trapping in dry and wet oxides on N-type 6H-SiC
- H. Choi, W. Wang and K. S. Trivedi 393 Analysis of conditional MTTF of fault-tolerant systems
- E. B. Hakim 403 Why use PEMs in military equipment: users' response

- M. Ehsanian, B. Kaminska and K. Arabi 409 A new on-chip digital BIST for analog-to-digital converters
- N. V. Hovanov, S. K. Kolganov, V. V. Kornikov and P. G. Popov 421 Complex objects quality estimation under uncertainty
- Yongxiang Zhao, Qing Gao and Jinnuo Wang 427 *Research Notes*  
A general isodegrading model for predicting mechanical equipment reliability and performance degradation
- Kuo-Hsiung Wang and Hui-Chen Lee 435 Cost analysis of the cold-standby M/M/R machine repair problem with multiple modes of failure
- L. Matthys, E. De Baetselier, W. Dobbelaere, W. Goedertier and G. De Mey 443 Calculation of thermoelastic stresses in microelectronics
- A. Brenner and U. Dinesh Kumar 449 Performance/dependability modelling using stochastic reward models: transient behaviour
- 455 World abstracts on microelectronics and reliability
- 471 Book reviews
- 479 Calendar of forthcoming events

## NUMBER 4

- N. Stojadinović and M. Pecht iii Editorial
- G. Meneghesso, F. Magistrali, D. Sala, M. Vanzi, C. Canali and E. Zanoni 497 *Introductory Invited Paper*  
Failure mechanisms due to metallurgical interactions in commercially available AlGaAs/GaAs and AlGaAs/InGaAs HEMTs
- P. Cova, F. Fantini and M. Manfredi 507 *Research Papers*  
Correlation between light emission and currents in pseudomorphic HEMTs
- Y. Haddab, D. Manic and R. S. Popovic 511 Persistent photoconductivity as a tool for monitoring oxide cluster concentration in silicon wafers
- Z. Gingl, C. Pennetta, L. B. Kiss and L. Reggian 515 A biased percolation model for the analysis of electronic-device degradation
- J. W. Evans, J. Y. Evans, P. Lall and S. L. Cornford 523 Thermomechanical failures in microelectronic interconnects
- E. M. Baskin 531 Methodology for creating "rejuvenating" devices
- D. Goguenheim, A. Bravaix, D. Vuillaume, M. Varrot, N. Revil and P. Mortini 539 Hot-carrier reliability in *n*-MOSFETs used as pass-transistors
- Chinho Lin, Jong-Mau Yeh and Jieh-Rern Ding 545 Design of random inspection rate for a flexible assembly system: a heuristic genetic algorithm approach
- P. Souverain, T. Camps, M. S. Faleh, A. Cazarré, J. Tasselli, A. Marty and J. P. Bailbé 553 Three-dimensional modeling of the heat flow into a GaAs substrate. Influence of thermal phenomena on the RF behavior of power HBTs and technological optimization
- A. Majumdar 559 Thermal microscopy and heat generation in electronic devices
- J. Jomaah and F. Balestra 567 Impact of latch phenomenon on low-frequency noise in SOI MOSFETs
- A. A. Ilumoka 571 A modular neural network approach to microelectronic circuit yield optimization

- P. Sharma, K. Upadhyayula, L. Lantz and M. Pecht 581 Impact of pre-conditioning, voltage bias and temperature on reliability of plastic encapsulated microcircuits
- Wei Li, Attahiru Sule Alfa and Yiqiang Q. Zhao 585 Stochastic analysis of a repairable system with three units and two repair facilities
- A. Žemva and B. Zajc 597 Functionality fault model: a basis for technology-specific test generation
- K. A. Mehdi and J. M. Kontoleon 605 Design and analysis of a self-testing-and-repairing random access memory "STAR-RAM" with error correction
- Ming-Dou Ker 619 Electrostatic discharge (ESD) protection for CMOS output buffers in scaled-down VLSI technology
- J. V. Manca, K. Croes, W. De Ceuninck, V. D'Haeger, J. D'Haen, P. Depauw, L. Tielemans and L. De Schepper 641 Localized monitoring of electromigration with early resistance change measurements
- L. Trabzon and O. O. Awadelkarim 651 Damage to n-MOSFETs from electrical stress: relationship to processing damage and impact on device reliability
- W. G. Schneeweiss 659 Fault tree analysis in case of multiple faults, especially covered and uncovered ones
- T. R. Tubbs and A. A. Gallo 665 Accelerated popcorn testing of high solder-reflow crack resistant molding compounds
- Yisong Dai, Yaqin Li and Jiansheng Xu 671 *Research Notes*  
Discussion on physical models for burst noise in a forward biased P-N junction and their experimental validation
- K. Takagi and T. Yamoto 677 A study on failure probability of a system including a protecting device
- E. B. Hakim 681 Plastic encapsulated microcircuit reliability prediction: why?
- M. Smotherman, W. T. Stinson and M. Chetuparambil 685 A hybrid model for weekday replacements with infant mortality failures
- M. P. Stoltz, P. Burgaud, F. Murgadella, J. P. Hirtz, P. Petit and A. Vervoitte 689 Reliability and qualification methodology of 60 W QCW linear bar arrays
- 697 Book reviews

## NUMBER 5

- J. J. Liou 709 *Introductory Review Paper*  
Long-term base current instability in AlGaAs/GaAs HBTs: physical mechanisms, modeling, and SPICE simulation
- R. M. Fricks and K. S. Trivedi 727 *Research Papers*  
Availability modeling of energy management systems
- V. A. Gritsenko, S. N. Svitaseva, i. P. Petrenko, Yu. N. Novikov, Yu. N. Morokov, Hei Wong, R. W. M. Kwok and R. W. M. Chan 745 Characterization of the silicon nitride-thermal oxide interface in oxide-nitride-oxide structures by ELS, XPS, ellipsometry, and numerical simulation
- A. M. Ionescu, A. Chovet, A. E. Popescu, A. Rusu and D. Steriu 753 Extraction method for source series resistance and transverse field mobility reduction coefficient using the MOSFET saturation region
- L. M. Perron, C. Hamaguchi, A. L. Lacaita, S. Maegawa and Y. Yamaguchi 759 Transient behavior and low  $V_{DS}$  hysteresis in PD SOI MOSFETs

A. Bonfiglio, M. B. Casu, F. Magistrali, M. Maini, G. Salmini and M. Vanzi	767	A different approach to the analysis of data in life-tests of laser diodes
S. Atkins, L. Teems, W. Rowe, P. Selby and R. Vaughters	773	Use of C-SAM acoustical microscopy in package evaluations and failure analysis
L. Dávid, B. Kovács, I. Mojzes, Zs. Kincses and L. Dobos	787	The electrical properties of Al/Ni/Ge/n-GaAs interfaces
A. Tixier, V. Senez, B. Baccus, A. Marmiroli, P. Colpani, A. Rebora and G. P. Carnevale	795	Influence of the silicon nitride oxidation on the performances of NCLAD isolation
W. G. Schneeweiss	807	Better graphs for dependability modeling
U. Menzel, R. Puchert, A. Bärwolff and A. Lau	821	<i>Research Notes</i> Facet heating and axial temperature profiles in high-power GaAlAs/GaAs laser diodes
E. Atanassova and D. Spassov	827	Electrical properties of thin Ta <sub>2</sub> O <sub>5</sub> films obtained by thermal oxidation of Ta on Si
E. Atanassova and T. Dimitrova	833	Carrier mobility in inversion layers of Si-thin Ta <sub>2</sub> O <sub>5</sub> structures
	839	Book reviews
	843	Calendar of forthcoming events

## NUMBERS 6-8

### SPECIAL ISSUE

#### RELIABILITY OF ELECTRON DEVICES, FAILURE PHYSICS AND ANALYSIS

C. Kjærgaard, F. Jensen	ix	Editorial
-------------------------	----	-----------

#### OPENING SESSION

D. Overhauser, J. R. Lloyd, S. Rochel, G. Steele, S. Z. Hussain	851	Full-chip reliability analysis
R. W. Thomas	861	An analysis of the quality and reliability supplement to the SIA roadmap

#### THEME 1: FAILURE ANALYSIS AND CHARACTERIZATION

D. Verkleij	869	The use of the focused ion beam in failure analysis
M. Rasras, I. De Wolf, H. Bender, G. Groeseneken, H. E. Maes, S. Vanhaeverbeke, P. De Pauw	877	Analysis of I <sub>ddq</sub> failures by spectral photon emission microscopy
K. Nikawa, T. Saiki, S. Inoue, M. Ohtsu	883	Near-field-optical-probe induced resistance-change-detection (NF-OBIRCH) method for identifying defects in Al and TiSi interconnects
M. Ciappa, P. Malberti, P. Furcas, M. Vanzi	889	A new adaptive amplifier for biased electron beam induced current applications
U. Mühle, A. Wiesner, S. Schray	895	Detailed investigation of SEM-results by TEM at one sample using FIB-technique
J. Benbrik, P. Perdu, B. Benteo, R. Desplats, N. Labat, A. Touboul, Y. Danto	901	Induced damages on CMOS and bipolar integrated structures under focused ion beam irradiation
G. Perez, F. Courtade, B. Benteo, J-L. Gauffier, J.L. Kwang	907	Junction delineation and EBIC on FIB cross section

- N. Hashikawa, K. Fukumoto, T. Kuroi, M. Ikeno, Y. Mashiko 913 Direct observation of local strain field for ULSI devices
- L. Pantisano, A. Paccagnella, L. Pettarin, A. Scarpa, G. Valentini, L. Baldi, S. Alba 919 A new experimental technique to evaluate the plasma induced damage at wafer level testing
- E. P. Vandamme, I. De Wolf, A. Lauwers, L. K. J. Vandamme 925 Low frequency noise analysis as a diagnostic tool to assess the quality of 0.25  $\mu\text{m}$  Ti-silicided poly lines
- E. Sheehan, P. K. Hurley, A. Mathewson 931 Hot carrier degradation mechanisms in sub-micron *p* channel MOSFETs: impact on low frequency (1/f) noise behaviour
- K. Yckache, P. Boivin, F. Baiget, S. Radjaa, G. Auriel, B. Sagnes, J. Oualid, A. Glachant 937 Reliability of nitrided wet silicon dioxide thin films in WSi<sub>2</sub> or TaSi<sub>2</sub> polycide process: influence of the nitridation temperature

## THEME 2: EOBT—ELECTRON AND OPTICAL BEAM TESTING

- L. Montelius, T. Junno, S.-B. Carlsson, M. H. Magnusson, K. Deppert, H. Xu, L. Samuelson 943 Assembly and analysis of quantum devices using SPM based methods
- J. Bangert, E. Kubalek 951 Circuit internal logic analysis with electric force microscope- (EFM-) testing
- G. B. M. Fiege, V. Feige, J. C. H. Phang, M. Maywald, S. Görlich, L. J. Balk 957 Failure analysis of integrated devices by scanning thermal microscopy (SThM)
- R. M. Cramer, W. R. Schade, R. Heiderhoff, L. J. Balk, R. Chin 963 Scanning near-field optical microscopy analyses of electronic devices
- S. Bae, A. Schlensog, W. Mertin, E. Kubalek, M. Maywald 969 A new test method for contactless quantitative current measurement via scanning magneto-resistive probe microscopy
- K. Miura, K. Nakamae, H. Fujioka 975 Automatic fault tracing by successive circuit extraction from CAD layout data with the CAD-linked EB test system
- V. Wittpahl, U. Behnke, B. Wand, W. Mertin 981 Cantilever influence suppression of contactless IC-testing by electric force microscopy
- C. Burmer, S. Görlich, S. Pauthner 987 Application of layout overlay for failure analysis
- S. Ito, H. Monma 993 Failure analysis of wafer using backside OBIC method

## THEME 3: FAILURE MECHANISMS AND MODELLING

- K. Bock, G. Groeseneken, H. E. Maes 997 ESD protection methodology for deep-sub-micron CMOS
- J. Van Olmen, J. V. Manca, W. De Ceuninck, L. De Schepper, V. D'Haeger, A. Witvrouw, K. Maex 1009 Overview of the kinetics of the early stages of electromigration under low (= realistic) current density stress
- R. Spolenak, O. Kraft, E. Arzt 1015 Effects of alloying elements on electromigration
- S. Foley, A. Scorzoni, R. Balboni, M. Impronta, I. De Munari, A. Mathewson, F. Fantini 1021 A comparison between normally and highly accelerated electromigration tests
- L. Arnaud, R. Gonella, G. Tartavel, J. Torrès, C. Gounelle, Y. Gobil, Y. Morand 1029 Electromigration failure modes in damascene copper interconnects
- A. Witvrouw, K. Maex, W. De Ceuninck, G. Leksens, J. D'Haen, L. De Schepper 1035 The dependence of stress induced voiding on line width studied by conventional and high resolution resistance measurements

P. Waltz, L. Arnaud, G. Lormand, G. Tartavel	1041	Lateral interface effect on pulsed DC electromigration analysis
V. Petrescu, A. J. Mouthaan, W. Schoenmaker, C. Salm	1047	Mechanical stress evolution and the Blech length: 2D simulation of early electromigration effects
J. A. Van Der Pol, P. B. M. Wolbert	1051	Systematic derivation of latchup design rules for submicron CMOS processes from test structures
P. Riess, R. Kies, G. Ghibaudo, G. Pananakakis, J. Brini	1057	Reversibility of charge trapping and SILC creation in thin oxides after stress/anneal cycling
G. H. Walter, W. Weber, R. Brederlow, R. Jurk, C. G. Linnenbank, C. Schlünder, D. Schmitt-Landsiedel, R. Thewes	1063	Precise quantitative evaluation of the hot-carrier induced drain series resistance degradation in LATID-n-MOSFETs
D. Manic, Y. Haddab, R. S. Popovic	1069	On-wafer heating tests to study stability of silicon devices
B. De Salvo, G. Ghibaudo, G. Pananakakis, F. Mondon	1075	Characterization of SILC in thin-oxides by using MOSFET substrate current
J. T. Park, B. J. Lee, D. W. Kim, C. G. Yu, H. K. Yu	1081	Hot carrier induced device degradation in RF-nMOSFET's
O. Buiu, S. Taylor, I. S. Al-Kofahi, C. Beech	1085	The effect of hot electron current density on nMOSFET reliability
A. Martin, R. Duane, P. O'Sullivan, A. Mathewson	1091	Dependence of gate oxide breakdown on initial charge trapping under Fowler-Nordheim injection
E. Vandenbossche, C. De Keukeleire, M. De Wolf, H. Van Hove, J. Witters	1097	Modelling and simulation of hot-carriers degradation of high voltage floating lateral NDMOS transistors
B. Marchand, G. Ghibaudo, F. Balestra, G. Guégan, S. Deleonibus	1103	A new hot carrier degradation law for MOSFET lifetime prediction
F. Ingvarson, L.-Å. Ragnarsson, P. Lundgren	1109	Recovery and stress dynamics in bipolar transistors and MOS devices
Ch. Mourrain, Ch. Tourniol, M. J. Bouzid	1115	Electrical parameters degradation law of MOSFET during ageing
J. Prendergast, N. Foley, J. Suehle	1121	Investigation of the intrinsic SiO <sub>2</sub> area dependence using TDDB testing and model integration into the design process
R. Rodríguez, E. Miranda, M. Nafria, J. Suñé, X. Aymerich	1127	Two-step stress method for the dynamic testing of very thin (8 nm) SiO <sub>2</sub> films
D. Uffmann	1133	Temperature dependence of snap back breakdown up to 300 C analyzed using circuit level model and simulation
H. Schleifer, O. Kowarik, K. Hoffmann, W. Reczek	1139	Modelling the field soft error rate of DRAMs by varying the critical cell charge
G. Setti, N. Speciale	1143	Design of a low EMI susceptibility CMOS transimpedance operational amplifier
B. Tala-Ighil, H. Toutah, A. Rahal, K. Mourgues, L. Pichon, F. Raoult, O. Bonnaud, T. Mohammed-Brahim	1149	Gate bias stress in hydrogenated and unhydrogenated polysilicon thin film transistors

#### THEME 4: FAILURE PREVENTION STRATEGIES

C. K. Hansen, P. Thyregod	1155	Use of wafer maps in integrated circuit manufacturing
E. Mino Diaz, J. E. Vila Aresté	1165	Field failure analysis on transmission data equipment due to lightning discharges

- P. Charpenel, P. Cavernes, V. Casanovas, J. Borowski, J. M. Chopin 1171 Comparison between field reliability and new prediction methodology on avionics embedded electronics
- A. G. M. Das, S. Johnson 1177 Improved reliability of bistable circuits by selective hot-carrier stress reduction
- A. Z. Wang, C. Tsay, A. Lele, P. Deane 1183 A study of NMOS behavior under ESD stress: simulation and characterization
- K. Croes, J. V. Manca, W. De Ceuninck, L. De Schepper, G. Molenberghs 1187 The time of "guessing" your failure time distribution is over!
- G. Härtler, U. Golze, K. Paschke 1193 Extended noise analysis - a novel tool for reliability screening

#### THEME 5: COMPOUND SEMICONDUCTOR AND OPTOELECTRONIC RELIABILITY

- G. Salviati, C. Zanotti-Fregonara, M. Borgarino, L. Lazzarini, L. Cattani, P. Cova, M. Mazzer 1199 Study of degradation mechanisms in compound semiconductor based devices by SEM cathodoluminescence
- T. Takeshita, M. Sugo, T. Nishiya, R. Iga, M. Fukuda, Y. Itaya 1211 Degradation behavior in InGaAs/GaAs strained-quantum well lasers
- A. Bonfiglio, M. B. Casu, M. Vanzi, R. De Palo, F. Magistrali, G. Salmini 1215 Early signatures for REDR-based laser degradations
- M. Morin, J.-P. Defars, P. Devoldère 1221 Coupling technology impact on low-cost laser modules performances and reliability
- G. Meneghesso, C. Crosato, F. Garat, G. Martinez, A. Paccagnella, E. Zanoni 1227 Failure mechanisms of Schottky gate contact degradation and deep traps creation in AlGaAs/InGaAs PM-HEMTs submitted to accelerated life tests
- L. Cattani, M. Borgarino, F. Fantini 1233 Pulsed current stress of berillium doped AlGaAs/GaAs HBTs
- T. Feng, N. Strifas, A. Christou 1239 Degradation of performance in MESFETs and HEMTs: simulation and measurement of reliability
- E. Martin, J. P. Landesman, P. Braun, A. Fily 1245 A new method for temperature mapping on GaAs field effect transistors

#### THEME 6: MICROSYSTEMS RELIABILITY

- R. De Reus, C. Christensen, S. Weichel, S. Bouwstra, J. Janting, G. Friis Eriksen, K. Dyrbye, T. Romedahl Brown, J. P. Krog, O. Søndergård Jensen, P. Gravesen 1251 Reliability of industrial packaging for microsystems
- C. Pellet, M. Lecouvé, H. Frémont, A. Val, D. Estève 1261 Analysis of thermomechanical stresses in a 3D packaged micro electro mechanical system
- D. Meunier, R. Desplats, J. Benbrik, G. Perez, C. Pellet, D. Estève, B. Benteo 1265 Electrical characterization and modification of a microelectromechanical system (MEMS) for extended mechanical reliability and fatigue testing
- J. B. Nysæther, A. Larsen, B. Liverød, P. Ohlckers 1271 Structures for piezoresistive measurement of package induced stress in transfer molded silicon pressure sensors

#### THEME 7: PACKAGING

- J. Barrett 1277 Electronic systems packaging: future reliability challenges
- Z. N. Liang, F. G. Kuper, M. S. Chen 1287 A concept to relate wire bonding parameters to bondability and ball bond reliability
- S. Dilhaire, A. Cornet, E. Schaub, C. Rauzan, W. Claeys 1293 Measurement of the thermomechanical behaviour of the solder-lead interface in solder joints by laser probing: a new method for measuring the bond quality

- P. Jansson 1297 Experimental design and evaluation of interconnection materials for improvement of joint reliability at power transistors
- S. Ramminger, P. Türkes, G. Wachutka 1301 Crack mechanism in wire bonding joints
- R. H. Esser, A. Dimoulas, N. Strifas, A. Christou, N. Papanicolaou 1307 Materials interfaces in flip chip interconnects for optical components; performance and degradation mechanisms
- Y. Etoh, T. Kayama, K. Sasaki 1313 A study of soldering heat evaluation for SMDs

**THEME 8: POWER DEVICES**

- H. Berg, E. Wolfgang 1319 Advanced IGBT modules for railway traction applications: reliability testing
- S. Januszewski, M. Kociszewska-Szczerbik, H. Świątek 1325 Some observation dealing with the failures of IGBT transistors in high power converters
- L. Galateanu, M. G. Stoica, E. Popa 1331 Strain depending reliability of automotive diodes
- C. Findeisen, E. Herr, M. Schenkel, R. Schlegel, H. R. Zeller 1335 Extrapolation of cosmic ray induced failures from test to field conditions for IGBT modules
- K. Nassim, L. Joannes, A. Cornet, S. Dilhaire, E. Schaub, W. Claeys 1341 Thermomechanical deformation imaging of power devices by electronic speckle pattern interferometry (ESPI)
- P. Cova, F. Fantini 1347 On the effect of power cycling stress on IGBT modules
- A. Hamidi, G. Coquery, R. Lallemand, P. Vales, J. M. Dorkel 1353 Temperature measurements and thermal modeling of high power IGBT multichip modules for reliability investigations in traction applications
- T. Franke, M. Honsberg-Riedl, P. Simon, J. Otto, S. Ramminger, G. Soelkner, E. Wolfgang 1361 On-chip reliability investigations on power modules actually working in inverter systems

I Author Index

**NUMBER 9****SPECIAL ISSUE****ADVANCES IN SUBMICRON MOS DEVICES AND TECHNOLOGY**

- H. Wong 1367 Editorial

**INSTABILITY AND RELIABILITY***Invited Papers*

- S. Nakajima, T. Ueki, Y. Shionoya, K. Mafune, N. Kuji, S. Nakamura, Y. Komine and T. Takeda 1369 Current status of failure analysis for ULSIs

- G. Groeseneken and H. E. Maes 1379 Basics and applications of charge pumping in submicron MOSFETs

*Research Papers*

- S.-C. Wong, M.-S. Huang, C.-Y. Sun and L.-M. Liu 1391 A phenomenon of charge trapping saturation induced by rapid thermal annealing
- K.-C. Leong, P.-C. Liu, K.-S. Yeo, C.-H. Gan, G. Qian, Y.-M. Lee and L. Chan 1401 Comparison of latchup immunity for silicided source/drain at different  $n^+$  implant energy
- M. Q. Huang, P. T. Lai, J. P. Xu, S. H. Zeng, G. Q. Li and Y. C. Cheng 1407 Suppression of hot-electron-induced interface degradation in metal-oxide-semiconductor devices by backsurface argon bombardment

## PHENOMENA OF GATE DIELECTRIC BREAKDOWN

- Invited Paper*
- H. S. Momose, S.-i. Nakamura, Y. Katsumata and H. Iwai 1413 Application of direct-tunneling gate oxides to high-performance CMOS
- Research Papers*
- L. Huang, P. T. Lai, J. P. Xu and Y. C. Cheng 1425 Mechanism analysis of gate-induced drain leakage in off-state n-MOSFET
- H. Wong and M. C. Poon 1433 Study of MOS gate dielectric breakdown due to drain avalanche breakdown
- C. L. Cha, E. F. Chor, H. Gong, A. Q. Zhang, L. Chan and J. Xie 1439 Evaluation of the dielectric breakdown of reoxidized nitrided oxide (ONO) in flash memory devices using constant current-stressing technique

## SIMULATION AND MODELLING

- Invited Paper*
- H.-S. P. Wong, Y. Taur and D. J. Frank 1447 Discrete random dopant distribution effects in nanometer-scale MOSFETs
- Research Papers*
- V. A. Gritsenko, Yu. N. Novikov, Yu. N. Morokov and H. Wong 1457 Simulation of electronic structure of Si-Si bond traps in oxide/nitride/oxide structure
- W.-I. Zhang and Z.-I. Yang 1465 A new threshold voltage model for deep-submicron MOSFETs with nonuniform substrate dopings

## FABRICATION TECHNOLOGY

- Invited Paper*
- R. Singh 1471 Sub-quarter micron silicon integrated circuits and single wafer processing
- Research Papers*
- C. Chan and S. Qin 1485 Plasma doping for ultra-shallow junctions
- B. L. Yang, E. C. Jones, N. W. Cheung, J. Shao, H. Wong and Y. C. Cheng 1489 n<sup>+</sup>/p ultra-shallow junction formation with plasma immersion ion implantation
- M. C. Poon, C. H. Ho, F. Deng, S. S. Lau and H. Wong 1495 Thermal stability of cobalt and nickel silicides
- M. C. Poon, M. Chan, W. Q. Zhang, F. Deng and S. S. Lau 1499 Stability of NiSi in boron-doped polysilicon lines
- J.-G. Su, S.-C. Wong and C.-T. Huang 1503 A study of tilt angle effect on Halo PMOS performance
- 1513 List of reviewers
- 1515 Calendar of forthcoming events

## NUMBER 10

- Introductory Invited Paper*
- J. H. Lau 1519 Solder joint reliability of a low cost chip size package—NuCSP
- Research Papers*
- P. Waltz, L. Arnaud, G. Lormand and G. Tartavel 1531 Influence of thermal heating effect on pulsed DC electromigration result analysis
- Y. Ousten, S. Mejdi, A. Fenech, J. Y. Deletage, L. Bechou, M. G. Perichaud and Y. Danto 1539 The use of impedance spectroscopy, SEM and SAM imaging for early detection of failure in SMT assemblies
- C. Leroux, P. Salome, G. Reimbold, D. Blachier, G. Guegan and M. Bonis 1547 Building in reliability with latch-up, ESD and hot carrier effects on 0.25  $\mu\text{m}$  CMOS technology

L. M. Perron, C. Hamaguchi, A. L. Lacaita, S. Maegawa and Y. Yamaguchi	1553	Experimental characterization of the continuous switching regime in floating-body PD SOI MOSFETs
N. Lukyanchikova, M. Petrichuk, N. Garbar, E. Simoen and C. Claeys	1561	RTS noise due to lateral isolation related defects in submicron $n$ MOSFETs
I. Mrak, M. M. Jevtić and Z. Stanimirović	1569	Low-frequency noise in thick-film structures caused by traps in glass barriers
K. N. Kim	1577	Optimal burn-in for minimizing cost and multiobjectives
P. T. Lai, J.-P. Xu, H. B. Lo and Y. C. Cheng	1585	Off-state gate current with quasi-zero temperature coefficient in $n$ -MOSFETs with reoxidized nitrided oxide as gate dielectric
S. Dilhaire, T. Phan, E. Schaub and W. Claeys	1591	Thermomechanical effects in metal lines on integrated circuits analysed with a differential polarimetric interferometer
Y.-C. Hsieh, T.-C. Chen and D. L. Bricker	1599	Genetic algorithms for reliability design problems
R. Mahajan and M. Pecht	1607	Reliability assessment of a plastic encapsulated RF switching device
D. Misra and P. K. Swain	1611	Strain relaxation in SiGe due to process induced defects and their subsequent annealing behavior
		<i>Research Notes</i>
K.-C. Leong, P.-C. Liu, H.-M. Ho, C.-H. Gan and L. Chan	1621	Impact of geometrical scaling on parasitic pnp bipolar transistor in $N$ -well, $0.25\ \mu\text{m}$ CMOS devices and its effect on latchup immunity
T. Yanagisawa	1627	The degradation of GaAlAs red light-emitting diodes under continuous and low-speed pulse operations
M. M. Jevtić	1631	Two-polarity pulse noise in reverse biased degraded p-n junctions
M. A. W. Mahmoud and M. A. Esmail	1639	Stochastic analysis of a two-unit warm standby system with slow switch subject to hardware and human error failures
	1645	Book review

## NUMBER 11

## SPECIAL ISSUE

## PAPERS PRESENTED AT THE 1997 SYMPOSIUM ON ELECTRICAL OVERSTRESS/ELECTROSTATIC DISCHARGE (EOS/ESD)

K. G. Verhaege	1647	Guest Editorial
		<i>Review Papers</i>
S. H. Voldman	1649	The impact of MOSFET technology evolution and scaling on electrostatic discharge protection
J. C. Smith	1669	ESD protection in thin film silicon on insulator technologies
G. Croft and J. Bernier	1681	ESD protection techniques for high frequency integrated circuits
T. J. Maloney	1691	Designing power supply clamps for electrostatic discharge protection of integrated circuits
J. Colvin	1705	ESD failure analysis methodology
L. G. Henry, T. Raymond, M. Mahanpour and I. Morgan	1715	ESD laboratory simulations and signature analysis of a CMOS programmable logic product

<i>Research Papers</i>	
P. Raha, J. C. Smith, J. W. Miller and E. Rosenbaum	1723 ESD robustness prediction and protection device design in partially depleted SOI technology
C. Richier, N. Maene, G. Mabboux and R. Bellens	1733 Study of the ESD behavior of different clamp configurations in a 0.35 $\mu\text{m}$ CMOS technology
G. Notermans	1741 On the use of n-well resistors in ESD protections
M. Chaine, S. Smith and A. Bui	1749 Unique ESD failure mechanisms during negative to Vcc HBM tests
P. Salome, C. Leroux, D. Mariolle, D. Lafond, J. P. Chante, P. Crevel and G. Reimbold	1763 An attempt to explain thermally induced soft failures during low level ESD stresses: study of the differences between soft and hard NMOS failures
W. Stadler, X. Guggenmos, P. Egger, H. Gieser and C. Musshoff	1773 Does the ESD-failure current obtained by transmission-line pulsing always correlate to human body model tests?
K. Bock	1781 ESD issues in compound semiconductor high-frequency devices and circuits
K. M. Lipka, P. Schmid, M. Birk, M. Demmler, J. Schneider, B. Splingart, P. J. Tasker, H. Heinecke and E. Kohn	1795 Novel concept for high level overdrive tolerance of GaAs based FETs
	1803 Calendar of forthcoming events

## NUMBER 12

<i>Research Papers</i>	
Y. Zhang, M. Pecht and L. Lantz	1811 A case study of IC storage failures in Taipei trains
S.-H. Renn and F. Balestra	1817 On the determination of the time-dependent degradation laws and device lifetime in deep submicron n- and p-channel SOI MOSFETs
Q. Kim and S. Kayali	1823 Microchannel gate temperature analysis
P. McCluskey, F. Lilie, O. Beysser and A. Gallo	1829 Low temperature delamination of plastic encapsulated microcircuits
Y. Z. Wang and O. O. Awadelkarim	1835 The effects of SiO <sub>2</sub> barrier between active layer and substrate on the performance and reliability of polycrystalline silicon thin film transistors
D. M. Mechtel, H. K. Charles Jr. and A. S. Francomacaro	1847 Laser-based electro-optic testing of multichip module structures
D. Rowlands, S. Dimitrijevic and H. B. Harrison	1855 The effects of process induced gate-to-source/drain junction separation in MOSFET structures
A. Ortiz-Conde, J. J. Liou, F. J. Garcia Sánchez, E. Gouveia Fernandes, O. Montilla Castillo, M. D. Rofiquel Hassan and G. De Mercato	1867 A new method for extracting the effective channel length of MOSFETs
Y. F. Hsieh and B. Y. Tsui	1871 Design rule related defects formation
Zs. Kohári, V. Székely, M. Rencz, A. Páhl, V. Dudek and B. Höflinger	1881 Studies on the heat removal features of stacked SOI structures with a dedicated field solver program (SUNRED)
A. Dziedzic, A. Magiera and R. Wiśniewski	1893 Hydrostatic high pressure studies of polymer thick-film resistors
A. G. M. Strollo and E. Napoli	1899 Power rectifier model including self heating effects

- |  |  |
|--|--|
| C.-K. Song, D.-Y. Kim, P.-J. Choi,<br>J.-H. Choi and D.-H. Kim                               | 1907 Degradation of AlGaAs/GaAs HBTs induced by hot carriers   |
| J. Horan and C. Lyden  | 1913 Rapid IC performance yield and distribution prediction using a rotation of the circuit parameter principals components                |
| S. Villa, G. De Geronimo, A. Pacelli,<br>A. L. Lacaita and A. Longoni                        | 1919 Application of $1/f$ noise measurements to the characterization of near-interface oxide traps in ULSI $n$ -MOSFETs                    |
| X. Zeng, P. T. Lai and J. P. Xu  | 1925 The effects of duty cycle and voltage swing of gate pulse on the AC-stress-induced degradation of $n$ MOSFETs with $N_2O$ gate oxides |
| <i>Research Notes</i>  |  |
| T. Seki and S. Yokoyama  | 1931 Analysis method of pooled data for accelerated life testing   |
| J. E. Pizano, T. H. Ma, J. O. Attia,<br>R. D. Schrimpf, K. F. Galloway<br>and A. F. Witulski | 1935 Total dose effects on power-MOSFET switching converters   |
| T. Lee, J. Lee and I. Jung   | 1941 Finite element analysis for solder ball failures in chip scale package  |
| E. Suhir and J. D. Weld  | 1949 Application of a 'surrogate' layer for lower bending stress in a vulnerable material of a tri-material body                           |
| C. Thomas, S. Haldar, M. Khanna,<br>S. Rajesh, K. K. Gupta and<br>R. S. Gupta                | 1955 Cut off frequency and transit time analysis of lightly doped drain (LDD) MOSFETs  |
| M. A. Manzoul  | 1963 Multi-function protective relay on FPGA   |
| P. Samanta and C. K. Sarkar  | 1969 New positive charge trapping dynamics in $SiO_2$ gate oxide, based on bulk impact ionization processes under Fowler-Nordheim stress   |
|  | 1975 Book reviews  |
|  | 1979 Contents of Volume 38   |
|  | 1993 Author Index to Volume 38   |

